PB-218 423

A REPORT ON THE EXHAUST EMISSIONS FROM A TURBOCHARGED VOLKSWAGEN

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Ann Arbor, Michigan

May 1971

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U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

71-28
PB 218 423
APTD-1415

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Springfield VA 22151

John C. Thomson
Bureau of Mobile Source Pollution Control
Office of Air Programs
ENVIRONMENTAL PROTECTION AGENCY

BIBLIOGRAPHIC DATA SHEET	1. Report No. APTD-1415	2.	3. Recipient's Accession No. PB-218 423
4. Title and Subtitle A Report on the Exhaust Emissions from a Turbocharged Volkswagen			5. Report Date May 1971 6.
7. Author(s) John C. Thomson			8. Performing Organization Rept. No.
9. Performing Organization Name and Address ENVIRONMENTAL PROTECTION AGENCY Bureau of Mobile Source Pollution Control Ann Arbor, Michigan			10. Project/Task/Work Unit No. 11. Contract/Grant No.
12. Sponsoring Organization Name and Address Same			13. Type of Report & Period Covered Inhouse 14.

15. Supplementary Notes

16. Abstracts

An evaluation of turbocharging and its effect on emissions was conducted on a 1971 Volkswagen that was equipped with a turbocharger retrofit package that consisted of a new exhaust system, a revised heater system and minor changes to fuel, oil and vacuum lines. The vehicle was a standard model using a four-speed manual transmission. The engine is a four-cylinder air-cooled opposed cylinder with 96 cu. in. displacement. The turbocharged vehicle was tested initially with the air concentration jet in the carburetor plugged and with a high idle CO concentration of 2.5 percent. The carburetor was then adjusted to 0.6 percent idle CO and with stock air correction jet reinstalled. The vehicle was tested without the turbocharger with idle CO set at 0.6 percent. The emission performance of the turbocharged engine was evaluated and its results were compared against the standard engine by using the 1972 Federal test procedure with a constant volume sampling system and the 1970 Federal test procedure using the 7-mode driving cycle. A standard performance test was also run. Results indicate that the turbocharger installation has no adverse effect on emissions when properly installed and adjusted. Emission results on the turbocharged vehicle with performance optimized.

17. Key Words and Document Analysis. 17a. Descriptors

Air pollution
Exhaust emissions
Automobiles
Superchargers
Turbomachinery
Tests
Standards
Performance tests
Sampling
Hydrocarbons
Carbon monoxide
Carbon dioxide
Nitrogen oxides

17b. Identifiers/Open-Ended Terms

Volkswagen
Retrofit devices
Federal Test Procedure (1972)
Constant Volume Sampling Technique
Federal Test Procedure (1970)

17c. COSATI Field/Group 13B

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Unlimited	UNCLASSIFIED	9
	20. Security Class (This Page) UNCLASSIFIED	22. Price $3.00/$0.95

Background

An evaluation of turbocharging and its effect on emissions was conducted on a 1971 Volkswagen supplied by the Schwitzer Division of the Wallace Murray Corporation.

Device Tested

The test vehicle was equipped with a turbocharger retrofit package that consisted of a new exhaust system, a revised heater system and minor changes to fuel, oil and vacuum lines. The turbocharger was driven by the hot exhaust gases in front of a muffler and intake air was ducted from the standard air filter to the turbocharger and then to the inlet of the carburetor. An electric fuel pump was installed to give the additional pressure required during high boost operation.

Test Program

The Volkswagen was initially received with the air correction jet in the carburetor plugged and a high idle CO concentration of about 2.5 percent CO. After the first test, the carburetor was adjusted to give a 0.6 percent CO reading at idle and the stock air correction jet was reinstalled. After running tests on the turbocharged vehicle, the complete kit was removed and the same vehicle was tested without the turbocharger with idle CO set at 0.6 percent. At the completion of this test, the Schwitzer representative requested additional tests on the VW using an idle CO of 2.4 percent.

This was a standard production Beetle using a four-speed manual transmission. The engine is a four cylinder air-cooled opposed cylinder with 96 cubic inch displacement. There were no internal modifications to the engine or drive train and all emission controls appeared to be operating.

In order to evaluate the emission performance of the turbocharged engine and to compare its results against the standard engine, two different emission tests were used. In Table I and Table II data is shown using the 1972 Federal emission test procedure. This test uses a closed cycle exhaust sampling system (Constant Volume Sampler) that collects all the exhaust continuously and samples a small portion. A non-repetitive driving schedule is used that is designed to closely duplicate average vehicle driving patterns. This test will be used for certification of 1972

and later model year automobiles and is completely described in the Federal Registers of November 10, 1970, February 27, 1971, and March 20, 1971.

The second test used is the 1970 Federal test procedure. This is the 7-mode open driving cycle made up of seven repeats of the 7-mode cycle. For this procedure exhaust emissions are measured directly from the tailpipe and a composite result is computed in grams per mile based on concentrations of pollutants and vehicle weight. These results are reported in Table III.

In addition to the emission tests a standard performance test was run to compare the vehicle with and without the turbocharger with lean idle. This is a full throttle acceleration test and the results are averages of two runs in opposite directions on the same day.

Results

A summary of the 1972 emission tests is reported in Table I. This data is an average of two or more tests taken under identical conditions. The complete test results are reported in Table II. Also reported in Table II are results taken from two similar Volkswagens in our fleet of surveillance cars. This data indicates that the results from the Volkswagen supplied by Schwitzer in stock condition closely compares with other Volkswagens we have tested. These results indicate the ability of the turbocharger kit to maintain emission levels when the system is properly adjusted. This kit actually showed a slight reduction although whether this is due to the turbocharger or slight differences in carburetor adjustment is unknown.

In Table III, the 1970 test results are reported for this car. The only test on the turbocharged version was as received with a very rich idle setting and a plugged air correction jet in the carburetor. This was the only test run under this condition and the carburetor was returned to stock condition before running any additional tests.

Table IV compares road performance of the turbocharged kit to the performance of the stock vehicle using the same carburetor settings. This shows the dramatic effect that the turbocharger has on the high speed performance reducing the 50-80 m.p.h. time from 30 to 20 seconds.

Conclusions

1. The turbocharger installation has no adverse effect on emissions when properly installed and adjusted.

2. Emission results on the turbocharged vehicle with performance optimized were above present standards. After proper adjustment this vehicle would meet 1972-1974 emission standards.

3. A considerable improvement in performance with turbocharger was found when comparing turbocharged and stock vehicle.

Table I

Emission Test Summary, Supercharged Volkswagon
1972 Federal Test Procedure Averages

	HC*	CO	CO_2	NO_x
Turbocharged (Lean Idle)	3.0	36	417	2.3
No Turbocharger (Lean Idle)	3.5	41	402	2.5
No Turbocharger (Rich Idle)	3.8	54	390	2.2
1973 Standards	3.4	39	---	3.0

* All results in grams per mile.

Table II

1972 Federal Test Procedure Emissions Summary

	HC	CO	CO_2	NOx
Turbocharged	3.1	40	456	2.8
(Lean Idle)	3.2	40	411	2.2
	2.6	29	383	2.0
No Turbocharger	3.1	39	411	2.4
(Lean Idle)	3.0	41	408	2.5
	4.3	42	397	2.6
No Turbocharger	4.1	56	398	2.0
(Rich Idle)	3.6	51	382	2.3
1969 Volkswagon (Surveillance Car)	4.2	42	331	1.2
1970 Volkswagon (Surveillance Car)	1.9	30	366	2.0

* All results reported in grams per vehicle mile.

Table III

1970 Federal Test Procedure Emissions Summary

	HC	CO	NOx
Turbocharged (Rich Idle & Modified jets)	2.3	42	1.8
No Turbocharger (Lean Idle)	1.6	18	2.0
No Turbocharger (Rich Idle)	2.2	28	1.8
Federal Standards for 1970 - 1971	2.2	23	---

* All results reported in grams per vehicle mile.

Table IV

Road Performance Data

Turbocharged (Lean Idle)	
20-50 m.p.h.	8.7 sec.
0-60 m.p.h.	14.0 sec.
50-80 m.p.h.	26.8 sec. (4th gear only) 19.9 sec. (3rd & 4th gear)

No Turbocharger (Lean Idle)	
20-50 m.p.h.	10.2 sec.
0-60 m.p.h.	16.4 sec.
50-80 m.p.h.	33.3 sec. (4thgear only) 29.8 sec. (3rd & 4th gear)